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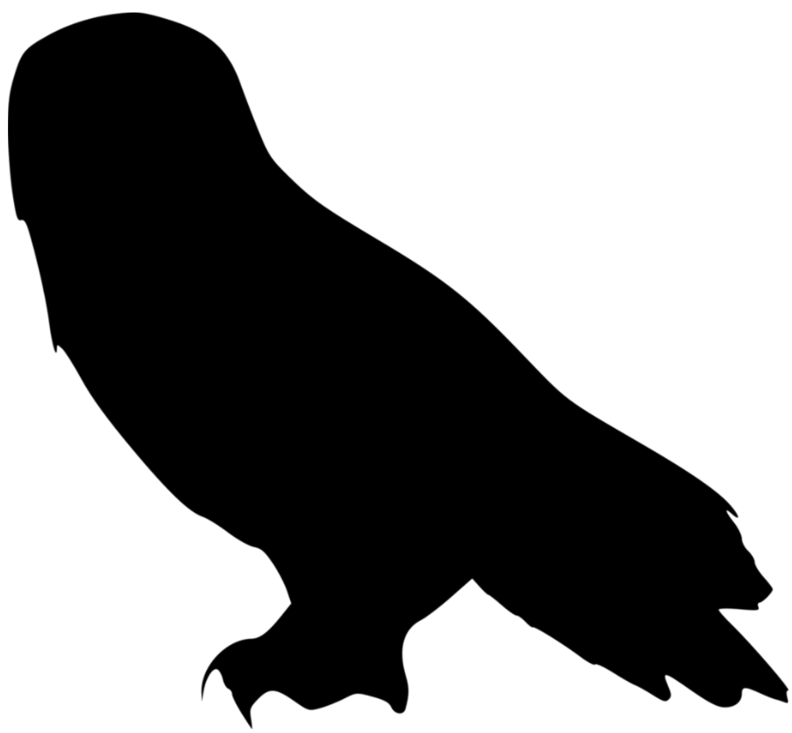

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THE USE OF CITIZEN SCIENCE DATA TO PREDICT THE WINTER DISTRIBUTION OF THE SNOWY OWL IN ONTARIO

by

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A CAUTION TO THE READER

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ABSTRACT

As an Anishinaabe person and environmental scientist, I feel I have an inherent duty to be a steward of the environment. I chose to conduct research on Snowy Owls after learning about the conservation issues affecting this species, namely habitat loss due to climate change. I hypothesized that using citizen science data and bioclimatic (BIOCLIM) variables would effectively predict the winter distribution of Snowy Owls in the province of Ontario s. I created a species distribution model (SDM) based upon occurrence data from the eBird and iNaturalist citizen science databases and bioclimatic variables using the computer software Maxent. The occurrence data was cleaned to a scale of 1-km^2 using QGIS to mitigate impacts of sampling biases in citizen science data. Though it had a relatively high AUC of 0.848, the final SDM was inaccurate in predicting the winter distribution of Snowy Owls in Ontario. Sampling biases inherent in citizen science data, possibly exacerbated by the permutation importance of the chosen BIOCLIM variables, were found to heavily skew the results of the SDM. The SDM indicated that Snowy Owls are more populous within Southern Ontario than Northern Ontario, and within developed areas highly populated by humans. Careful consideration of sampling biases and their magnitude of impact is recommended when developing an SDM based upon data acquired via citizen science databases. Further research with alternative methodologies is required to develop an appropriate SDM of winter occurrence of Snowy Owls in Ontario.

CONTENTS

ACKNOWLEDGEMENTS

I thank my supervisor Dr. Brian McLaren and mentor Dr. Will Wilson for their unwavering support and guidance during this research project and throughout my post-secondary career at Lakehead University. I also thank Ms. Vianney Janice Cupiche Herrera for her irreplaceable help and effectiveness as a second reader, and Mr. Tomislav Sapic for helping me with any hiccups I encountered while using QGIS. Furthermore, I thank my mother for encouraging me and giving me the opportunity and confidence to pursue my dreams and ambitions.

INTRODUCTION AND OBJECTIVES

INTRODUCTION

I'm an Anishinaabe person from Lake Helen Reserve, just north of Nipigon, Ontario, and I chose to conduct this research project in part due to my cultural background. I feel a strong drive to fulfil my role as a steward of the environment, and I sought to take this opportunity to tell a story about conservation. We have now begun to experience visible impacts of climate change across the world, yet the global demand for resources is expected to increase exponentially still (UN Environment 2019). I wanted to take a snapshot of the possible implications on wildlife, now, as we pass the point of no return, to advocate for the genuine and effective conservation of wildlife and habitat in Ontario.

I started off my project by conducting a thorough literature review. I considered various sources that covered different aspects of owl biology to both broaden and deepen my understanding of my subject taxon. Once I'd developed a solid foundational knowledge of owls, I started reading journal articles about habitat selection of Snowy Owls. I decided to further focus my study on the winter distribution of Snowy Owls in the province of Ontario.

I chose the Snowy Owl (*Bubo scandiacus*) (Figure 1) as my subject species for a few reasons. One is that it is an incredibly charismatic and distinctive species known by many people regardless of location or education. I anticipate that these are traits that will facilitate its role as a flagship species in conservation biology. Another reason is its life history and habitat; the polar regions where it breeds are experiencing impacts of a rising global temperature, which may put these habitats at risk of destruction (van Beest et al. 2021). This may increase the value of the winter habitat of this species, which extends throughout Ontario.

The objective of my research project is to estimate the current winter distribution of the Snowy Owl in Ontario. I hypothesized that using citizen science data and bioclimatic (BIOCLIM) variables would effectively predict the winter distribution of Snowy Owls in the province of Ontario.

Figure 1. Snowy Owl photographed in Quebec, Canada (Hemmings 2010).

LITERATURE REVIEW

Experiential Insight

Donald S. Heintzelman (2011) combines years of experiential knowledge in his book, *Guide to Owl Watching in North America*. Although the text does not include any legal or official protocols, it goes into detail about time dependant (i.e., diurnal and nocturnal) as well as situation dependant (i.e., nesting and roosting owls) owl watching methods; survey equipment specifications; and owl watching sites across North America that have granted him successful observations. There are also sections devoted to the biology and natural history of owls, in which Heintzelman describes and elaborates on how this knowledge can be used to increase one's owl watching successes.

Another book that is filled with fantastic anecdotal insight into the practice and payoffs of ornithological fieldwork is Scott Weidensaul's (1999) *Living on the Wind: Across the Hemisphere with Migratory Birds*. In this work, Weidensaul, a renowned figure in the relatively small world of ornithology, uses writing that is accessible and down to earth. The massive journey of North American avian migration is broken down into several small migrations, allowing the reader to approach the topic from a new and more accurate perspective. The author describes his experiences observing various bird migrations, and what he's learned from witnessing one of the most dynamic trans-continental biological processes firsthand.

Biological and Reference Guides

Wayne Lynch's (2007) textbook, *Owls of the United States and Canada: A Complete Guide to Their Biology and Behaviour*, is loaded with information that is not only incredibly in-depth, but also far-reaching in its subject matter. Covering all nineteen owl species that can regularly be found in North America, this text delves into the surprising evolution, specialized adaptations, puzzling behaviour, and cryptic lives of these nocturnal raptors. Lynch also ensures to include various human cultures, historic and modern, when describing our relationships with owls and our impacts on them.

Scott Weidensaul (2015) has authored the most comprehensive resource I have located so far, the *Peterson Reference Guide to Owls of North America*, which consolidates in-depth information on each of the nineteen owl species of North America, as well as twenty additional species in the Caribbean. Each species account is bolstered by a bibliography containing great resources including scientific peer-reviewed journal articles, research papers, museum archives, and field guides. Weidensaul does not limit himself to resources written in the English language; many of his cited works are written in Spanish. This allows the information and perspective provided by many countries and people from North America and the Caribbean to be shared with many who would ordinarily not be able to access it.

<u>Protocols and Guidelines</u>

The Birds Canada (2021) *Ontario Nocturnal Owl Survey – Nocturnal Owl Surveys in Northern Ontario: A Citizen's Guide* document details the protocol for conducting nocturnal owl surveys in northern Ontario, intended to aid Birds Canada citizen scientists. Based upon owl data gathered in northern Ontario, this guide discusses basic and advanced owl surveying methods, locations, and equipment in a manner that is accessible and digestible by the average citizen scientist.

The *Ontario Northern Hawk Owl* survey instruction manual, written by Kevin Hannah, provides specific instructions regarding the surveying of Northern Hawk Owls (*Surnia ulula*). Several traits distinguish the Northern Hawk Owl from other owl species, one of which is the fact that they are diurnal. Thus, information regarding surveying methods designed with this as the target species is extremely valuable to this research paper, as the research area for this project is within the range of this species.

Kathy Jones' (2021) *Ontario Barred and Northern Saw-whet Owl survey instruction manual* provides specific instructions regarding the surveying of Barred (*Strix varia*) and Northern Saw-whet (*Aegolius acadicus*) Owls in Ontario. Information regarding surveying methods designed with this as the target species is especially valuable to this research paper, as the research area for this project is within the Barred Owl's range, a more frequently observed species.

The *Ontario Long-eared Owl survey instruction manual* by Bernie Ladouceur (2021) provides specific instructions regarding the surveying of Long-eared Owls (*Asio* *otus*) in Ontario. Information regarding surveying methods designed with this as the target species is extremely valuable to this research paper, as the research area for this project is within the Barred Owl's range.

Julia Shonfield's (2021) *Ontario Great Gray and Boreal Owl survey instruction manual* provides specific instructions regarding the surveying of Great Gray (*Strix nebulosa*) and Boreal (*Aegolius funereus*) Owls in Ontario. Information regarding surveying methods designed with this as the target species is especially valuable to this research paper, as the research area for this project is within the Great Gray Owl's range.

The *Guidelines for Nocturnal Owl Monitoring in North America* authored by Lisa Takats et al. (2001) details guidelines for owl survey protocols that were developed consequently proceeding a meeting discussing the lack of owl-specific protocols and the inefficiency of basing protocols on data collected during multi-species surveys (Takats et al. 2001). This text discusses the elements that should be considered when developing protocol for nocturnal owl surveys (Takats et al. 2001).

<u>Reports and Assessments</u>

In COSEWIC's 2020-2021 annual report to the Minister of Environment and Climate Change and the Canadian Endangered Species Conservation Council, the Short-eared Owl is mentioned as one of the species newly classified by COSEWIC as "Threatened" (COSEWIC 2021). It is important to have up to date information regarding the status and wellbeing of a species whose range extends into the research area (Lynch 2007 and COSEWIC 2008).

In COSEWIC's April 2008 assessment of the Short-eared Owl, the species' classification of "Special Concern" under COSEWIC's criteria is announced and defended (COSEWIC 2008). It is important to have up to date information regarding the status and wellbeing of a species whose range extends into the research area (Lynch 2007 and COSEWIC 2008). The fact that the Short-eared Owl is a Species of Special Concern adds urgency to the completion of this research, especially as climate change puts the winter habitats of this species in peril (COSEWIC 2008).

Databases

I reviewed Snowy Owl occurrence data using the Global Biodiversity Information Facility (GBIF) database. GBIF allows the user to see species distributions across the world, filtering by location, species, and additional parameters (GBIF 2023). GBIF has an amalgamation of various species occurrence datasets from around the world, which makes it one of the most comprehensive databases available. I focused on data from the eBird and iNaturalist datasets due to their popularity with professionals and citizen scientists. The Snowy Owl has been commonly observed throughout the province of Ontario by professional and citizen scientists when they have migrated south for the winter (eBird 2023, iNaturalist 2023).

Winter Ecology of the Snowy Owl

The Snowy Owl is the only owl species in Northern Ontario that migrates south to Ontario during the winter, often in irruptive patterns (Lynch 2007, Weidensaul 2015, and Therrian et al. 2017). Migration routes along waterbodies are preferred over routes across agricultural croplands (McCabe et al. 2021). Many Snowy Owls are nomadic throughout their winter range, which is an important and complex element to consider when interpreting occurrence data and mapping the distribution of this species (Therrian et al. 2017, Robillard et al. 2018, McCabe et al. 2021).

When selecting winter home ranges, it appears that many Snowy Owls are drawn to habitats that morphologically resemble the landscapes dominating their summer range (i.e., more open undisturbed habitats such as tundra, steppes; Table 1; Therrian et al. 2017). Morphological traits shared by the winter and summer tundra habitat often used by this species include short, shrubby vegetation, a relatively even elevation, and high levels of visibility (i.e., less 'visual clutter' in the form of trees, shrubbery, and sudden changes in elevation). Furthermore, Snowy Owls exhibit high site fidelity to their winter home ranges yet are flexible and mobile when using this space (Robillard et al. 2018). It is hypothesized that these traits may facilitate their survival and success during the climate change crisis (Robillard et al. 2018).

Table 1. Habitat classes used by female Snowy Owls in the 2014 – 2015 winter season (Therrian et al. 2017).

Individual	Three most occupied habitat classes	Proportion surrounding owl location
		Percent
Chippewa	Grassland/pasture/agriculture	58
	Open water	23
	Developed	11
Delaware	Barren	51
	Open water	27
	Developed	13
Orleans	Grassland/pasture/agriculture	91
	Developed	4
	Open water	3
Prairie Ronde	Grassland/pasture/agriculture	93
	Developed	5
	Forested / open water	1
Reedsville	Grassland/pasture/agriculture	53
	Open water	32
	Developed	12
Whitefish	Grassland/pasture/agriculture	68
	Wetland	22
	Developed	4

MATERIALS AND METHODS

STUDY AREA

The province of Ontario is in east-central Canada and is approximately 1,076,395 km^2 in size. It is bordered by Hudson’s Bay to the north and the Great Lakes to the south. The unique functions, composition, and structure of Ontario’s landscapes provide many ecological resources for Snowy Owls. According to the Ontario Land Cover Compilation, some of the land cover types present within Ontario are shoreline, wetlands (marshes, fens, bogs, swamps), tundra/heath, forests (coniferous, deciduous, mixed), tallgrass prairies, bedrock, open cliffs, agricultural, and industrialized (MNRF 2014). Ontario is composed of four main climatic regions based upon the Köppen climate classification system (Figure 2).

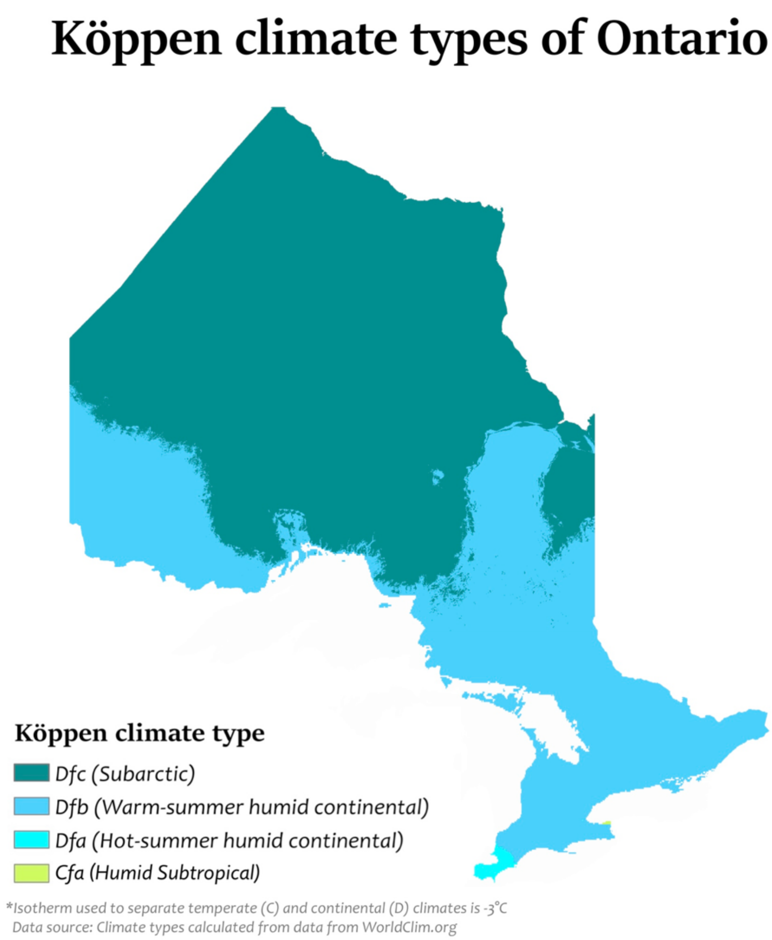

Figure 2. Köppen climatic regions of Ontario (Peterson 2016 [CC BY 4.0]).

MAXENT SPECIES DISTRIBUTION MODEL

I decided to answer my hypothesis by creating a species distribution model (SDM) using the open-source computer software Maxent (Phillips et al. n.d.). Maxent was designed to utilize presence-only data to predict a species' spatial distribution, and because of this, Maxent can sufficiently account for and mitigate some sampling biases commonly associated with modelling from presence-only data (Phillips et al. 2006; Merow et al. 2013). Maxent makes a prediction of a species' distribution by comparing presence localities with selected environmental variables. During this process, Maxent makes a categorical prediction of the probability of species presence within each raster cell (Phillips et al. 2006; Merow et al. 2013). It's able to do this via prior training with the data during the 'training phase'. A large portion of the presence locality data is allocated to train the model, and the remaining records are used in the final test run. I elected to use 80% of my species occurrence data in the testing phase, and the remaining 20% in the final test run. I chose a relatively low testing percentage to reduce the chance of overfitting the model. When a model becomes overfit, it performs poorly because it follows the training data too closely and is thus unable to accurately predict new data during the test run.

SPECIES OCCURRENCE DATA

To obtain the species occurrence data for my SDM, I submitted an online data query to GBIF. I chose to use data from the eBird and iNaturalist datasets due to the familiarity I gained with them during the literature review and their common application in SDM creation (Ivanova & Shashkov 2021). I filtered the results to ensure that I would obtain appropriate data to test my hypothesis (Table 2).

Table 2. Filters used during species occurrence data query via GBIF (GBIF 2023).

Filter Type	Selected Filter
Taxon	*Bubo scandiacus*
Dataset	eBird Observation Dataset, iNaturalist Research-grade Observations
Spatial Extent	CAN.9_1 (Ontario)
Month	November, December, January, February, March
Year	2000-2023
Occurrence Status	Present

With the filters in place, I submitted my data query and received 33,908 results. I then cleaned my species occurrence data to reduce the impact of sampling biases in the SDM, such as by removing multiple observations of the same individual, initially any occurrences points within a buffer of 250-m due to the highly nomadic nature of Snowy Owls during the winter. However, filtering at this scale did not sufficiently mitigate the bias, so a broader scale of 1-km^2 was chosen. A great degree of sampling bias remains evident in the dissonance between the number occurrence points within Northern and Southern Ontario (Figure 3). With no context, it appears as though Snowy Owls are more populous throughout Southern Ontario. This is largely due to the relatively massive population of Southern Ontario compared to that of Northern Ontario (>13 million vs. <750 thousand; Statistics Canada 2021), as well as the level of development (i.e., accessibility) of the landscape. After filtering, I was left with 8,496 occurrence points to use in Maxent.

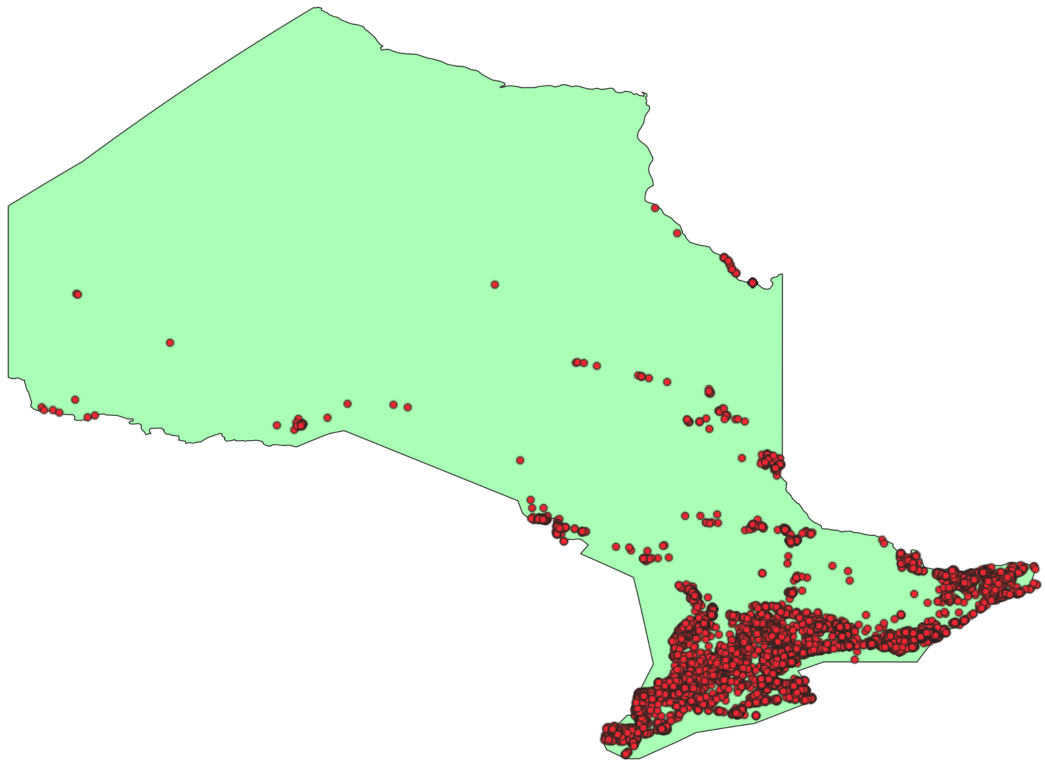

Figure 3. Snowy Owl occurrence data post-cleaning.

ENVIRONMENTAL LAYERS

Bioclimatic Variables

I downloaded historic (1970-2000) BIOCLIM data from the WorldClim database to create a model predicting the current condition of the SDM. All BIOCLIM data was obtained at spatial resolution of 30 seconds (~1-km^2) to increase geospatial accuracy when projecting the completed SDM onto the Ontario Land Cover Compilation raster. Not all the BIOCLIM variables were used to create the SDM, as not all of them were relevant (i.e., useful) in constructing the model. Using QGIS, an open-source Geographic Information System (GIS) computer software, I clipped all 19 of the BIOCLIM raster files to the extent of Ontario. This was done to match the scope of the environmental variables to the scope of the research project. I then performed an intervariable correlation analysis using the r.covar function in Geographic Resources Analysis Support System (GRASS) integration plugin in QGIS (Appendix 1). This was done to increase the performance of the SDM; highly correlated variables provide very similar impacts on the SDM, which increases the risk of skewed or inaccurate results. Variables with a correlation value of >0.7 were considered highly correlated. Seven highly correlated variables were removed based upon the results of the correlation analysis: BIO-01, BIO-06, BIO-09, BIO-11, BIO-14, BIO-17, and BIO-19.

In addition, during the subsequent training phase in Maxent, jackknife tests were performed to cross-validate the impact each variable had on the SDM, specifically its area under the ROC curve (AUC), which provides an aggregated measure of SDM performance (Merow et al. 2013). Based upon the results of the jackknife tests, 4 BIOCLIM variables were removed that were highly correlated or unimportant to SDM permutation (BIO-03, BIO-13, BIO-16, and BIO-18), leaving eight variables to be used during the final test run.

During the test run, Maxent produced a table describing the permutation importance of each variable on the SDM (Table 3), which allowed for the interpretation of each variable's magnitude of impact on the SDM's predictions. Based on these results, the most important variables were BIO-10, BIO-15, BIO-05, and BIO-04. In retrospect, two of these variables (BIO-10 and BIO-05) may have been ill-suited in estimating winter habitat distribution, as they describe BIOCLIM conditions occurring during the summer.

Table 3. Percentage of each environmental variable's permutation importance in the SDM.

Variable	Variable description	Permutation importance (%)
BIO-10	Mean temp. warmest quarter	53.4
BIO-15	Precip. seasonality	26.1
BIO-05	Max. temp. warmest month	8.4
BIO-04	Temp. seasonality	6.2
BIO-07	Temp. annual range	4.2
BIO-02	Mean diurnal range	1.0
BIO-12	Annual precip.	0.5
BIO-08	Mean temp. wettest quarter	0.4

Ontario Land Cover Compilation

After creating my SDM using the species occurrence data and the BIOCLIM variables, I compared it to the Ontario Provincial Land Cover Compilation dataset. This is a raster dataset compiled from three different land cover sources that each cover a different spatial scope of the province: the Provincial Land Cover 2000 Edition, the Southern Ontario Land Resource Information System version 1.2, and the Far North Land Cover version 1.4 (MNRF 2014). This was done to determine whether there is any correlation between the SDM's predicted presence locations and land cover classification (inferred as habitat type). To facilitate this assessment, the number of land cover classes were reduced from 29 to 5 by combining classes based upon morphology (Table 4).

RESULTS

I performed 22 runs on Maxent using different combinations of environmental variables, which were selected based upon the intervariable correlation analysis results. SDM-8 was considered the best performing model because it has the highest AUC, with a value of 0.848 (Figures 4, 5 and 6).

Table 4. Revised and original land cover classification (MNRF 2014).

Revised Land Cover Classification	Ontario Provincial Land Cover Compilation Classification
Open Water	Clear Open Water, Turbid Water
Open Habitat	Shoreline, Mudflats, Marsh, Fen, Bog, Heath, Sparse Treed, Open Cliff and Talus, Alvar, Sand Barren and Dune, Open Tallgrass Prairie, Tallgrass Savannah, Bedrock, Agriculture and Undifferentiated Rural Land Use
Forested Habitat	Swamp, Treed Upland, Deciduous Treed, Mixed Treed, Coniferous Treed, Plantations - Treed Cultivated, Hedge Rows, Tallgrass Woodland
Infrastructure/Disturbance	Disturbance, Sand/Gravel/Mine Tailings/Extraction, Community/Infrastructure
Other	Other, Cloud/Shadow

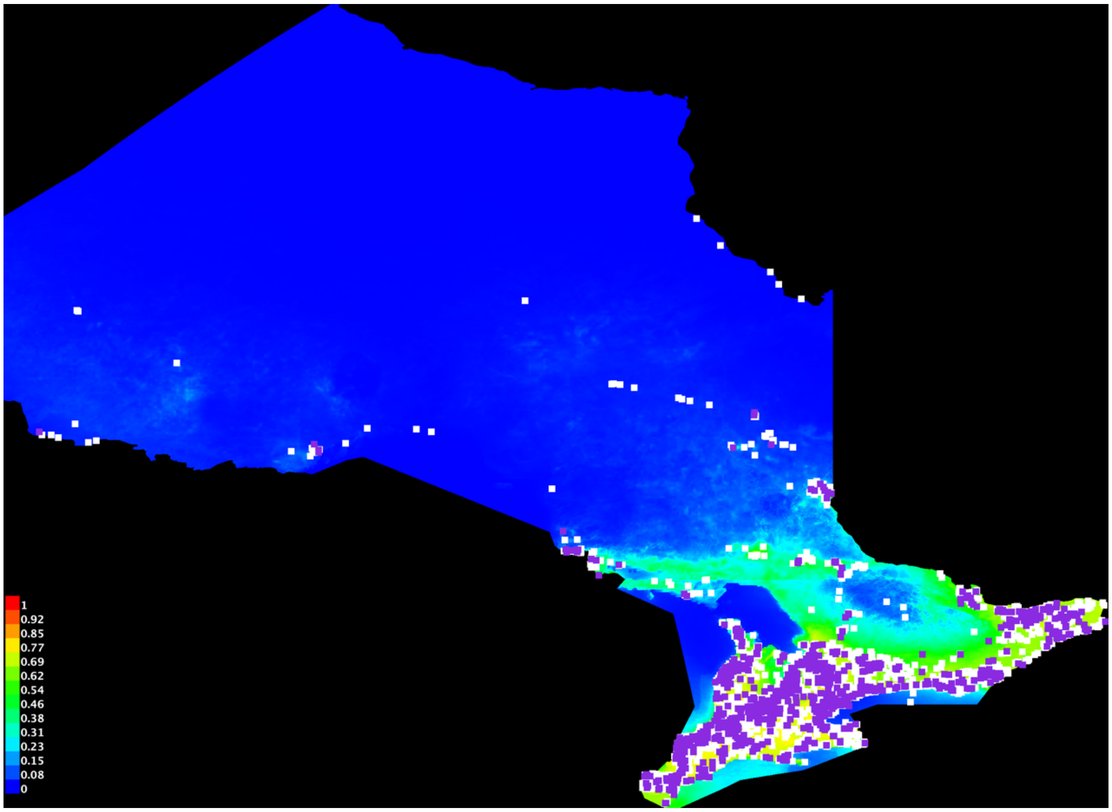

Figure 4. Map illustrating SDM of Snowy Owls in Ontario.

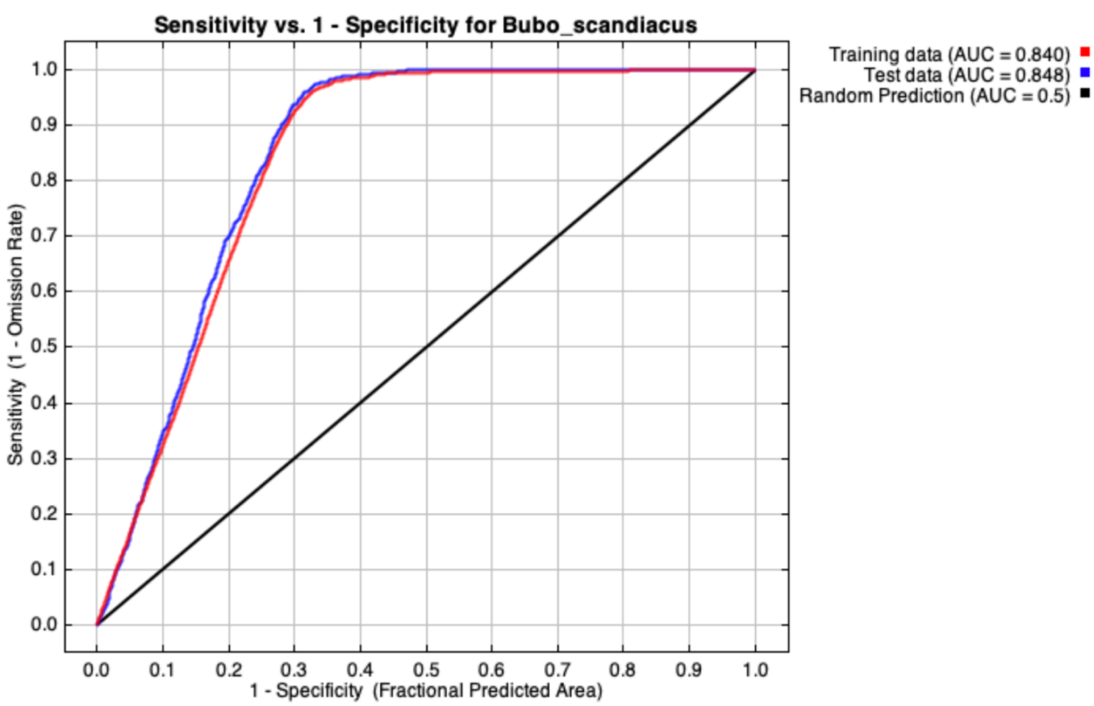

Figure 5. ROC curve and associated AUC for training data, testing data, and random predictions.

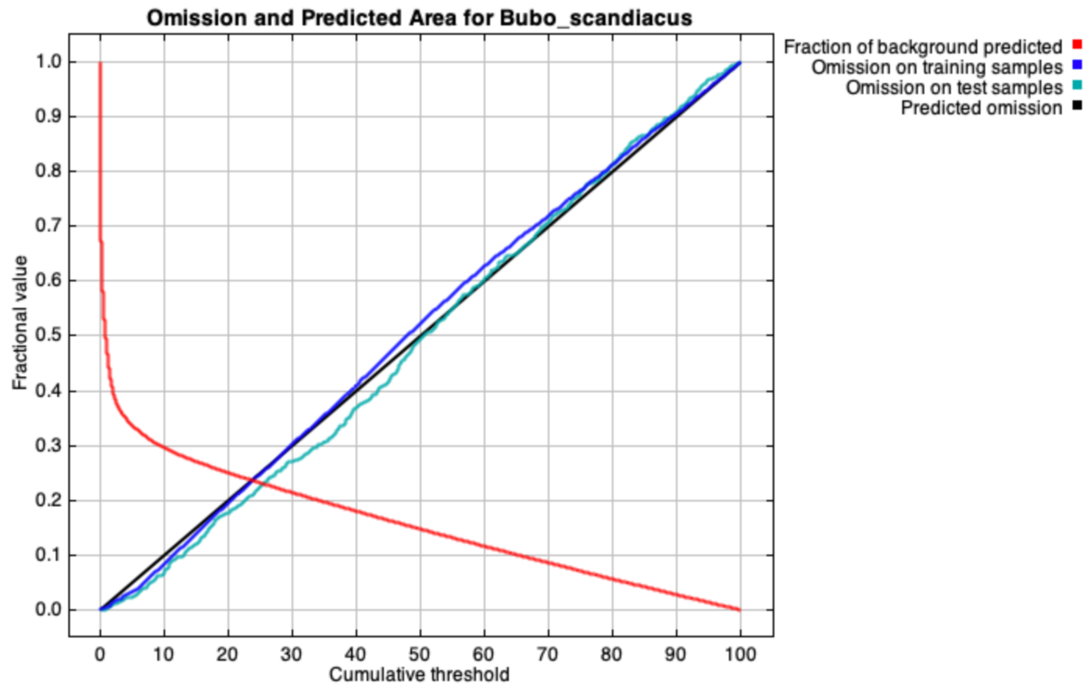

Figure 6. Omission rate and predicted area of Snowy Owl SDM.

DISCUSSION

Despite its high AUC and testing gain values, and the measures taken to mitigate sampling bias, the SDM was heavily skewed and therefore performed poorly. Thus, using solely presence only data and BIOCLIM variables is not sufficient in estimating the current winter distribution of the Snowy Owl in Ontario. Due to the magnitude of sampling bias, the SDM likely more accurately reflects the winter distribution of humans in Ontario rather than that of the Snowy Owl. The effects of sampling bias may have been exacerbated by the low number of environmental variables used to build the SDM, magnifying the influence of each variable. One possible mitigative augmentation would be using the Provincial Land Cover data as environmental variables when creating the

SDM in Maxent, rather than simply projecting the completed SDM onto the Provincial Land Cover raster.

Many of the species occurrence data were recorded along roadways and residential landscapes (GBIF 2023). This is an example of a variation in sampling effort over space; a sampling bias inherent to citizen science data (Dickison et al. 2010). In this situation, space more easily accessible to humans is often oversampled, while less accessible space is often undersampled. The large spatial scope of this project (i.e., the province of Ontario) compared to the area surveyed may have magnified the impacts of these biases and reduced mitigation efficacy. Careful consideration should be used when filtering and cleaning data gathered via citizen science to sufficiently account for and eliminate sampling biases.

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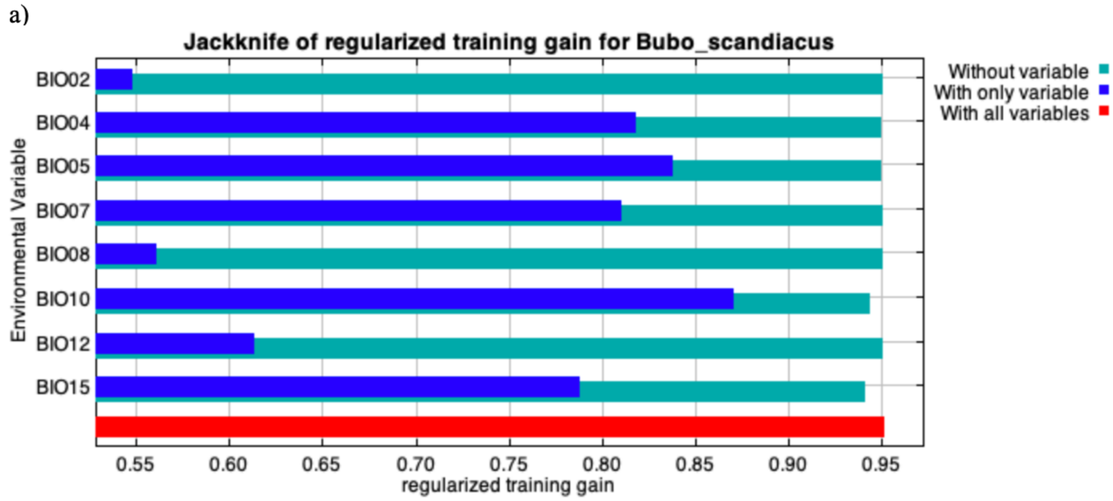

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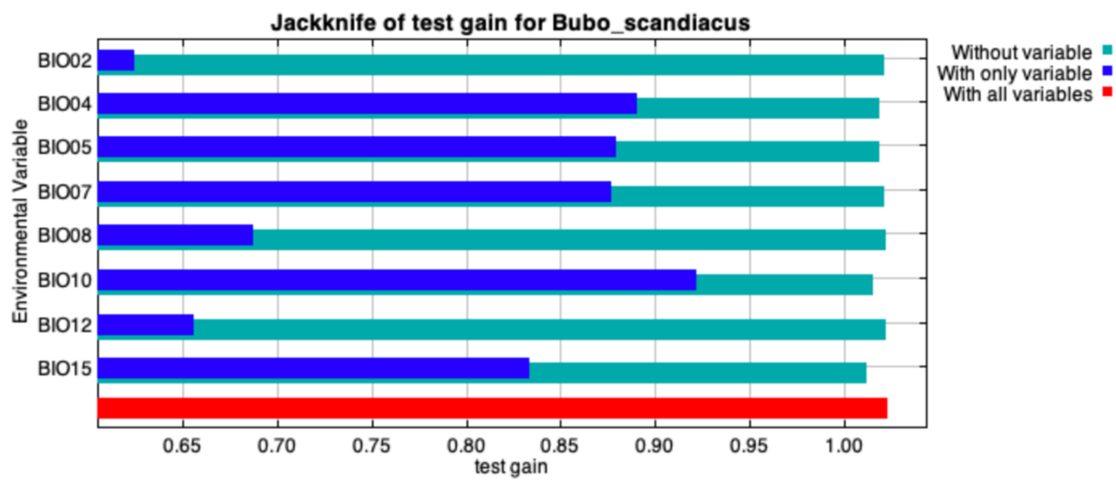

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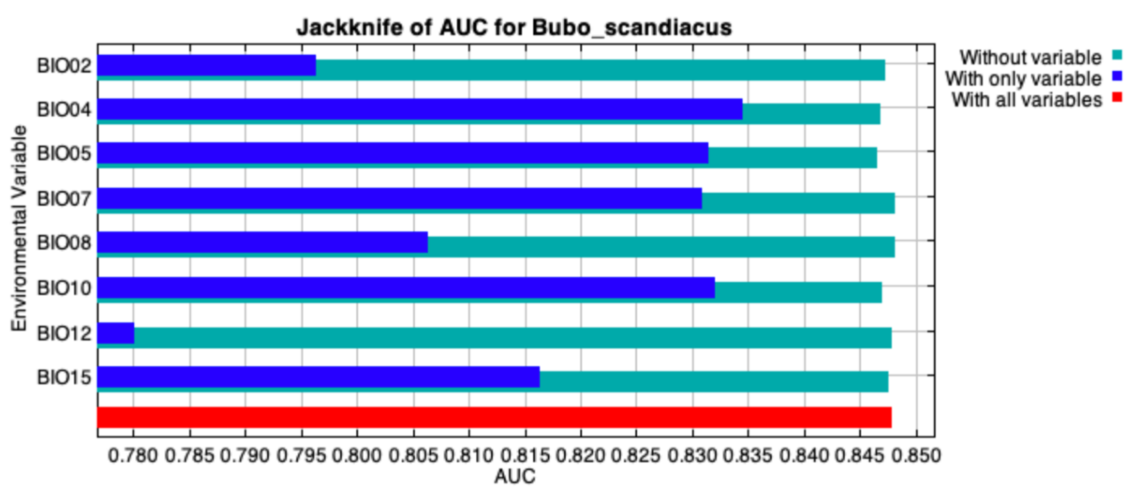

Figure 7. Jackknife test of variable importance using three separate parameters: training gain (8a), test gain (8b), and test AUC (8c).

The fact that BIO-10 (mean temperature warmest quarter) has the highest permutation importance value (Table 3) may have also played a role, as the SDM indicates a positive correlation between Snowy Owl presence and said variable. This influence may have been exacerbated by BIO-10 potentially being positively correlated with human presence in Ontario. In retrospect, BIO-05 (maximum temperature warmest month), the third most influential variable, should have been excluded from the SDM due to being outside of the temporal scope of the research project.

Aside from the intervariable correlation analysis, the SDM was trained and evaluated solely based upon its AUC and testing gain values. This was evidently the incorrect approach and more careful consideration should have been taken to ensure that the SDM better reflected the preferred habitats of the target species (Lobo et al. 2007). Doing this would have illuminated many examples of the same error being made in scientific literature about Maxent and species distribution modeling, such as in Fourcade et al.'s (2013) study *Confronting expert-based and modelled distributions for species with uncertain conservation status: A case study from the corncrake* (*Crex crex*). This study also resulted in a biased and poorly performing SDM with a high AUC value (0.85).

CONCLUSION

Using citizen science data and BIOCLIM variables was not effective in predicting the winter distribution of Snowy Owls in Ontario, outweighed by the impacts of sampling biases inherent to citizen science data. The results of the Maxent SDM indicate that Snowy Owls are highly present in disturbed/urban areas; this is due to sampling bias skewing the performance of the SDM. No conclusive information about Snowy Owl presence can be inferred from the results of the SDM generated in Maxent due to excessive sampling biases (i.e., the number of occurrences in Southern Ontario compared to Northern Ontario). Further research is needed to fulfill the established objectives of this research project; it is anticipated that a broader application of environmental variables in addition to BIOCLIM data, as well as a more careful approach in the training phase, will facilitate the mitigation of these sampling biases.

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APPENDIX 1

Table 5. Results of intervariable correlation analysis.

BIO-01	1																		
BIO-02	-0.449454	1																	
BIO-03	0.656312	0.274517	1																
BIO-04	-0.921261	0.563727	-0.62823	1															
BIO-05	0.757513	0.064035	0.638872	-0.471641	1														
BIO-06	0.962743	-0.633319	0.54606	-0.968286	0.586058	1													
BIO-07	-0.882249	0.739722	-0.441118	0.969573	-0.384356	-0.973283	1												
BIO-08	-0.179473	0.319488	-0.113601	0.319268	0.094587	-0.296163	0.364239	1											
BIO-09	0.832378	-0.390069	0.625699	-0.85695	0.525303	0.837099	-0.804898	-0.351477	1										
BIO-10	0.920383	-0.31462	0.54322	-0.700224	0.909314	0.818185	-0.674529	-0.021368	0.666946	1									
BIO-11	0.983606	-0.52801	0.642603	-0.974943	0.641373	0.989089	-0.945177	-0.256689	0.860057	0.840164	1								
BIO-12	0.832378	-0.390069	0.625699	-0.85695	0.525303	0.837099	-0.804898	-0.351477	1	0.666946	0.860057	1							
BIO-13	0.457343	-0.030571	0.454859	-0.430073	0.301681	0.389482	-0.35827	-0.217581	0.436069	0.395766	0.439085	0.436069	1						
BIO-14	0.837764	-0.239369	0.769526	-0.840915	0.611161	0.820453	-0.761601	-0.419825	0.847057	0.688135	0.854467	0.847057	0.463162	1					
BIO-15	-0.819652	0.169116	-0.814131	0.831653	-0.611555	-0.792339	0.729458	0.305882	-0.826923	-0.659905	-0.838339	-0.826923	-0.340782	-0.962481	1				
BIO-16	0.493246	-0.030961	0.481559	-0.442635	0.358904	0.419968	-0.376789	-0.243708	0.413722	0.453996	0.465554	0.413722	0.933703	0.512278	-0.379796	1			
BIO-17	0.858462	-0.238178	0.781352	-0.849164	0.639093	0.833452	-0.768497	-0.407924	0.843541	0.719102	0.869504	0.843541	0.477223	0.990836	-0.96701	0.532119	1		
BIO-18	0.117214	0.303825	0.263169	-0.010616	0.218291	-0.017696	0.08202	0.396577	-0.053122	0.187612	0.048382	-0.053122	0.626597	-0.003036	0.045453	0.66615	0.016485	1	
BIO-19	0.789863	-0.24908	0.729401	-0.815076	0.536213	0.78483	-0.742252	-0.518891	0.860952	0.625368	0.815667	0.860952	0.523648	0.974288	-0.925495	0.557131	0.970118	-0.025975	1
	BIO-01	BIO-02	BIO-03	BIO-04	BIO-05	BIO-06	BIO-07	BIO-08	BIO-09	BIO-10	BIO-11	BIO-12	BIO-13	BIO-14	BIO-15	BIO-16	BIO-17	BIO-18	BIO-19